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DEPARTMENT OF TRANSPORTATION
Federal Aviation Administration
14 CFR Part 121
[Docket No. FAA-2000-________; Notice No.___________]
RIN 2120-___________
Operations in Icing Conditions
AGENCY: Federal Aviation Administration (FAA), DOT.
ACTION: Notice of proposed rulemaking (NPRM).

SUMMARY: This proposal would amend the regulations applicable to operators of certain airplanes used in air carrier service and certificated for flight in icing. The proposal would require either the installation of ice detection equipment or changes to the Airplane Flight Manual to ensure timely activation of the ice protection system. This proposal also would require certain actions applicable to airplanes with reversible flight controls for the pitch and/or roll axis. This proposed regulation is the result of information gathered from a review of icing accidents and incidents, and it is intended to improve the level of safety when airplanes are operated in icing conditions.

DATES: Send your comments on or before [*90 days after date of publication in the Federal Register.*]

ADDRESSES: Address your comments to the Docket Management System, U.S. Department of Transportation, Room Plaza 401, 400 Seventh Street, SW., Washington,

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ADDRESSES: Address your comments to the Docket Management System, U.S. Department of Transportation, Room Plaza 401, 400 Seventh Street, SW., Washington, DC 20590-0001. You must identify the docket number FAA-2000-__________ at the beginning of your comments, and you should submit two copies of your comments. If you wish to receive confirmation that FAA received your comments, include a self-addressed, stamped postcard.

You may also submit comments through the Internet to http://dms.dot.gov. You may review the public docket containing comments to these proposed regulations in person in the Dockets Office between 9:00 a.m. and 5:00 p.m., Monday through Friday, except Federal holidays. The Dockets Office is on the plaza level of the NASSIF Building at the Department of Transportation at the above address. Also, you may review public dockets on the Internet at http://dms.dot.gov.
FOR FURTHER INFORMATION CONTACT: Kathi Ishimaru, FAA, Propulsion/Mechanical Systems Branch, ANM-112, Transport Airplane Directorate, Aircraft Certification Service, 1601 Lind Avenue SW., Renton, WA 98055-4056; telephone (425) 227-2674; facsimile (425) 227-1320, e-mail kathi.ishimaru@faa.gov.
SUPPLEMENTARY INFORMATION:
Comments Invited

Interested persons are invited to participate in the making of the proposed action by submitting such written data, views, or arguments as they may desire. Comments relating to the environmental, energy, federalism, or economic impact that might result from adopting the proposals in this document also are invited. Substantive comments should be accompanied by cost estimates. Comments must identify the regulatory docket or notice number and be submitted in duplicate to the DOT Rules Docket address specified above.

Handout 19

All comments received, as well as a report summarizing each substantive public contact with FAA personnel concerning this proposed rulemaking, will be filed in the docket. The docket is available for public inspection before and after the comment closing date.

All comments received on or before the closing date will be considered by the Administrator before taking action on this proposed rulemaking. Comments filed late will be considered as far as possible without incurring expense or delay. The proposals in this document may be changed in light of the comments received.

Commenters wishing the FAA to acknowledge receipt of their comments submitted in response to this document must include a pre-addressed, stamped postcard with those comments on which the following statement is made: "Comments to Docket No. FAA-2000-___________." The postcard will be date stamped and mailed to the commenter.

Availability of NPRMs

Internet users may reach the FAA's web page at http://www.faa.gov/avr/arm/nprm/nprm.htm or the GPO's web page at http://www.access.gpo.gov/nara for access to recently published rulemaking documents.

Any person may obtain a copy of this document by submitting a request to the Federal Aviation Administration, Office of Rulemaking, ARM-1, 800 Independence Avenue SW., Washington, DC 20591, or by calling (202) 267-9680. Communications must identify the notice number or docket number of this NPRM.

Persons interested in being placed on the mailing list for future rulemaking documents should request from the above office a copy of Advisory Circular No. 11-2A, Notice of Proposed Rulemaking Distribution System, which describes the application procedure.

BACKGROUND

On October 31, 1994, an accident involving an Aerospatiale Model ATR72 series airplane occurred in which icing conditions, believed to include freezing drizzle droplets, were reported in the area. The FAA, Aerospatiale, the French Direction Générale de l'Aviation Civile, Bureau Enquete Accident, National Aeronautics and Space Administration (NASA), National Transportation Safety Board (NTSB), and others have conducted an extensive investigation of this accident. This investigation has led to the conclusion that freezing drizzle conditions created a ridge of ice aft of the deicing boots and forward of the ailerons, which resulted in uncommanded roll of the airplane.

Existing Regulations

Certification Regulations. The current regulations that are applicable to flight in icing conditions are contained in Title 14, Code of Federal Regulations (CFR) Part 23 (§ 23.1419, "Ice protection") for small airplanes, and Part 25 (§ 25.1419, "Ice protection") for transport category airplanes. Both of these regulations require that an airplane must be able to safely operate in the continuous maximum and intermittent maximum icing conditions of 14 CFR Part 25, Appendix C. Appendix C characterizes continuous maximum and intermittent maximum icing conditions within stratiform and cumuliform clouds. Freezing precipitation (freezing drizzle and freezing rain) are not included. Appendix C defines icing cloud characteristics (for both small and transport airplanes) in terms of mean effective drop diameters, liquid water content, temperature, horizontal extent, and altitude. Icing conditions containing freezing drizzle and freezing rain sometimes result in mean effective diameters that are larger than the mean effective drop diameters defined in Appendix C. Consequently, these icing conditions containing freezing drizzle and freezing rain are not considered during the certification of the airplane's ice protection system, and exposure to these conditions could result in hazardous ice accumulations.

Operating Regulations. 14 CFR Part 121.629(a) states:

> No person may dispatch or release an aircraft, continue to operate an aircraft enroute, or land an aircraft when in the opinion of the pilot in command or aircraft dispatcher (domestic and flag operations only), icing conditions are expected or met that might adversely affect the safety of the flight.

Also, 14 CFR Part 121.341 requires certain types of ice protection equipment and wing illumination equipment to be installed.

Neither the operating regulations nor the certification regulations require a means for the pilot in command to specifically identify that hazardous icing conditions have been met.

NTSB Safety Recommendations

The NTSB issued various safety recommendations to the FAA following the Model ATR72 accident. One of the recommendations, A-96-56, states in part that:

> If safe operations in certain icing conditions cannot be demonstrated by the manufacturer, operational limitations should be imposed to prohibit flight in such conditions and flight crews should be provided with the means to positively determine when they are in icing conditions that exceed the limits for aircraft certification.

In response to the latter portion of this safety recommendation, the FAA tasked the Aviation Rulemaking Advisory Committee (ARAC), by notice published in the Federal Register on December 8, 1997 (62 FR 64621), to:

> . . . consider the need for a regulation that requires installation of ice detectors, aerodynamic performance monitors, or another acceptable means to warn flight crews of ice accumulation on critical surfaces requiring crew action (regardless of whether the icing conditions are inside or outside of Appendix C of 14 CFR Part 25).

The Aviation Rulemaking Advisory Committee (ARAC)

The ARAC was formally established by the FAA on January 22, 1991 (56 FR 2190), to provide advice and recommendations concerning the full range of the FAA's safety-related rulemaking activity. The FAA sought this advice to develop better rules in less overall time, using fewer FAA resources than are currently needed. The committee provides the opportunity for the FAA to obtain firsthand information and insight from interested parties regarding proposed new rules or revisions of existing rules.

There are 64 member organizations on the committee, representing a wide range of interests within the aviation community. Meetings of the committee are open to the public, except as authorized by section 10(d) of the Federal Advisory Committee Act.

The ARAC establishes working groups to develop proposals to recommend to the FAA for resolving specific issues. Tasks assigned to working groups are published in the Federal Register. Although working group meetings are not generally open to the public, all interested parties are invited to participate as working group members. Working groups report directly to the ARAC, and the ARAC must accept a working group proposal before that proposal can be presented to the FAA as an advisory committee recommendation.

The activities of the ARAC will not, however, circumvent the public rulemaking procedures. After an ARAC recommendation is received and found acceptable by the FAA, the agency proceeds with the normal public rulemaking procedures. Any ARAC participation in a rulemaking package will be fully disclosed in the public docket.

The rulemaking proposal contained in this notice is based on a recommendation developed by the Ice Protection Harmonization Working Group (IPHWG) of ARAC that ARAC approved and presented to the FAA as a recommendation.

DISCUSSION

Review Process

To address the task, the IPHWG followed a process consisting of the following five elements:

1. Review of the airplane icing related accident/incident history,
2. Identification of safety concerns,
3. Identification of the airplanes subject to the safety concerns (i.e., applicability),
4. Identification of various means to address the safety concerns, and
5. Review of the technology available to allow compliance with any proposed methods of addressing the safety concerns.

These five elements are discussed in more detail below.

1. Accident/Incident History Review

The IPHWG reviewed the airplane icing-related accident/incident history and developed a database of approximately 1,300 worldwide icing-related accidents and incidents. The IPHWG then refined the database by:

- Removing duplicate entries and reports with insufficient data.
- Removing elements that were not relevant to inflight airframe icing problems, such as reports related to ground deicing and carburetor icing.
- Excluding single-engine piston airplanes, because most of these airplanes are not certificated for flight in icing. (Although a few of these airplanes may be

certificated and equipped for flight in icing, the IPHWG considered that their exclusion would not affect the outcome of the review.)

- Removing reports involving multi-engine piston airplanes that were not certificated for flight in icing.
- Removing reports of events in which externally aggravating circumstances existed, such as operation of the airplane outside of its weight and balance limitations, descent below published minimums, or other reasons not related to airplane icing.

The IPHWG reviewed the remaining events and identified 96 events that contained adequate information to apply the following criteria:

- Was there ice accretion that was not known to the flight crew? and
- Would knowledge of this ice accretion have made a difference to the outcome of the accident or incident?

Based on these 96 events, the IPHWG concluded that in at least 61 events, there is substantive documented accident and incident history in which the existing level of flight crew cognizance of ice buildup on airframe surfaces was not adequate.

Once the group had concluded that flight crew cognizance of ice buildup on airframe surfaces was not adequate, an effort was undertaken to further analyze the data in order to identify factors which play a role in the flight crew's situational awareness as it pertains to icing. A parallel effort was undertaken to identify aerodynamic and system design factors which might play a role in the susceptibility of the airplane to icing effects, thus influencing the procedural vigilance required of the flight crew.

Both of these efforts required that the database be expanded. To do this, the same refinements described above were applied to the 1,300-event database, except that reports were included in which there was not sufficient information to positively determine whether flight crew knowledge of the ice accretion would have made a difference to the outcome of the accident or incident. This review yielded 234 events.

All 234 events were used to examine aerodynamic and system design factors. However, in order to look at issues regarding the flight crew's situational awareness, single pilot operations were not considered relevant to multi-pilot aircrew cognizance. Therefore, events which were likely to have involved a single pilot were removed from the 234 events for this purpose. This left 119 events.

During the review of the 96-event data set, certain factors became apparent and these were evaluated more closely using the 119-event data set. In particular, factors which affect crew workload were considered, such as phase of flight and crew complement.

Crew complement was estimated based on the number of pilots required by the type certificate and/or the type of operation being conducted. Phase of flight was extracted from the narratives of the events.

This part of the analysis revealed that 49% of the 119 events had taken place during the approach and landing phases of flight, 38% had taken place during the cruise phase, 8% during the climb phase, and 2% during the go-around phase.

The phase-of-flight analysis was conducted again using only accidents. The pattern remains similar: 73% of the accidents had taken place during approach and landing, 17% during cruise, 7% during climb, and 2% during go-around.

Reported incidents represent a smaller portion of total incidents than reported accidents do of total accidents. However, if the proportion of reported incidents to total incidents is assumed to remain the same across all phases of flight, the relationship of accidents to incidents in each phase becomes of interest. It was found that in the case of approach and landing, there occurred just over 3 accidents for every reported incident. In the case of the cruise phase, there occurred 0.3 accidents for every reported incident; in the case of climb, 0.4 accidents for every reported incident.

This led the IPHWG to consider why the approach and landing phases were apparently much more likely to result in an event than the cruise and climb phases, and why that event was much more likely to be an accident.

The approach and landing phases of flight involve considerably higher degrees of pilot workload than do the cruise and climb phases. Thus, there is less attention available to manage the ice accretion problem. Further, these phases involve continuous changes in flight parameters such as airspeed, altitude, and bank angle. Therefore, indications of ice accretion other than visual cues, such as trim changes and drag increases, are much less visible to the crew. Finally, research was considered which suggests that the drag effects of ice accreted at low angles of attack can become very significant when the angle of attack is increased. Ice accreted early in the approach phase may not manifest its effects until the angle of attack is increased later in the approach or landing.

All of these factors influence the situation while the airplane is in close proximity to the ground.

The pilot workload required varies. In all cases, it requires that the ice accretion be detected. In some cases, it then requires that the ice accretion be evaluated prior to operation of the ice protection system (IPS).

With this data in hand, further work was undertaken to examine the crew response to knowledge of ice accretion. In 122 events out of 234, the narrative contained information that the flight crew knew that ice was accreting on the airframe. Yet in only 48 cases was there positive evidence that the crew had operated the IPS. This did not seem to be affected by crew complement, with 20 of the 48 cases involving a single pilot. In 16 of these cases, there was positive evidence that the crew had not operated the IPS; in the remainder, no information regarding IPS operation was available.

The IPHWG also considered extensively the significant air carrier accidents and incidents in recent years due to icing. These included the accidents at Roselawn, Indiana, in 1994 and at Monroe, Michigan, in 1997. It also included incidents involving Fokker F-27s at East Midlands, UK, and Copenhagen, Denmark; the British Aerospace ATP at Cowley, UK; Embraer EMB-120s at Tallahassee, Elko, Fort Smith, and Klamath Falls, US, and several Aerospatiale/Alenia ATR events during the 1980s. In nearly all of these cases, the flight crew was aware of ice accretion yet did not feel it warranted activation of the IPS. In other cases, notably the ATR at Mosinee, Wisconsin, the crew was completely unaware of clear ice accretion during approach.

2. Safety Concerns

Activation of Airframe IPS. The airplane icing-related accident/incident history review revealed accidents and incidents where the flight crew either:

- Was completely unaware of ice accumulation on the airframe, or

- Was aware of ice accumulation but judged that it was not significant enough to warrant operation of the IPS.

This led the IPHWG to conclude that flight crews must be provided with a clear means to know when to activate the IPS.

Exit Icing Conditions. The database contains accidents and incidents where the IPS was operated according to accepted procedures, yet the ice accretions still created degradations that led to an event. Therefore, the IPHWG concluded that the flight crew must be provided with a means to know if the airplane is in conditions conducive to ice accumulation that warrant the flight crew taking actions to exit icing conditions.

3. Applicability

The IPHWG examined the 234-event accident and incident history and found that discriminating factors exist that significantly reduce the risk of icing accidents and incidents. A wide range of factors was considered, including airplane size, type of flight control system, and wing chord length.

A limited analysis of the event database described above revealed that average wing chord length has a roughly inverse relationship to the event history. Of the data considered, the IPHWG noted that airplanes with average chord lengths in excess of ten feet had not experienced any accidents due to in-flight icing. Although some airplanes with shorter chords have no event history, many do.

Evidence is available to show that contamination on the upper wing surface results in an increasing deterioration in the wing's coefficient of lift and the coefficient of drag as the ratio of surface roughness height to chord length increases. This may sufficiently influence the contamination effects in a typical icing encounter such that a large chord experiences minimal aerodynamic effect, while a small chord may experience significant effects. Another contributing factor for the lack of accidents may be the fact that for any given icing encounter, droplets will impinge further aft and the resulting ice shape will be larger on a short chord wing than on a longer chord wing. Chord length, then, may be an appropriate discriminator for determining which airplanes have a higher risk of accidents and incidents without the flight crew having a clear means to know when to activate the IPS and when to exit icing conditions.

However, chord length is not a commonly known attribute of the airplane; therefore, the IPHWG sought a simple discriminator that could be readily understood by the aviation community. In the accident/incident database, those airplanes with a ten-foot average chord correspond quite well with airplanes with a weight of 60,000 pounds. Since the maximum certificated gross takeoff weight is simple and well-understood, it was recommended as the discriminating parameter.

4. Possible Means of Addressing the Safety Concerns

The FAA has issued Airworthiness Directives (AD's) to require activation of pneumatic deicing boots at the first signs of ice accumulation on several types of airplanes operated under 14 CFR Part 121. These AD's relieve the pilot of determining whether the amount of ice accumulated on the wing warrants activation of the IPS. However, the flight crew's observation of ice accumulations can be difficult during times of high workload, operations at night, or when clear ice has accumulated. Also, the difficulties of observing ice accumulations is applicable to any IPS which relies on this observation for activation of the system, not just pneumatic deicing boots.

The IPHWG concluded that an improved means to address these situations would be to require installation of a device that would alert the flight crew that the IPS should be activated. An advisory ice detection system in conjunction with substantiated visual cues will provide a much higher level of safety than visual cues alone. This device would mitigate the effects of high workload and of human sensory limitations in detecting ice and evaluating its thickness. When using such a device in conjunction with a manual ice protection system as required in 121.XXX (a)(2), the IPHWG considers it is not acceptable to use crew assessment of depth of ice as a discriminator in deciding when to operate the de-icing system. The intent is to permit current certified manual systems to be used in such a way that they replicate the effectiveness of an automatic system without the dependency on the crew to establish ice depths. There are several types of airplanes currently in operation which have primary ice detection systems installed, and the IPHWG considers that these airplanes already meet the desired level of safety.

An alternative to requiring the installation of such an ice detector would be to require that the IPS be operated continuously when the airplane is operating in conditions conducive to airframe icing: reference 121.XXX (b)(1). In this case, the flight crew would operate the ice protection system in response to a specific air temperature threshold and the presence of visible moisture. Temperature and visible moisture information is readily available and unambiguous. This approach has disadvantages with respect to increased maintenance due to increased time in operation. However, it presents large advantages with respect to flight crew workload and procedural reliability. It is consistent with systems used as anti-ice systems and is the procedure in use for many thermally anti-iced small jets. The IPHWG noted that small jets that used these procedures were absent from the incident data base. When a manual de-icing system is required to be operated as defined above, the IPHWG considers it is not acceptable to use crew assessment of depth of ice as a discriminator in deciding when to operate the de-icing system. The intent is to permit current certified manual systems to be used in such a way that they replicate the effectiveness of an automatic system without the dependency on the crew to establish ice depths. The IPHWG considered that this procedure could be used as an alternative to an ice detector.

Minority Position - BAE Systems (Supported by Cessna Aircraft Company)

The Part 121 Icing Ops rule proposed by the IPHWG has 3 options for demonstrating compliance with part (a) and (b) when flying in conditions conducive to airframe icing as follows:

(a) (1) Airplane must be equipped with a primary ice detection system or,
(2) Substantiated visual cues and an advisory ice detection system or,
(b) (1) & (2) Mandate continuous operation of the ice protection system at various phases of flight.

BAE Systems cannot support the proposed Part 121 Operational rule parts (a) and (b) due to the inability of a Part 121 rule to recognize compliance by an equivalent level of safety. The proposed rule has been developed to recognize that some aircraft types demonstrate unacceptable performance or handling characteristics in icing conditions. The incident and accident database was analyzed to determine a potential configuration that is susceptible to unsafe characteristics. The result of that analysis is that any aircraft of less than 60,000lbs would be affected by the introduction of this rule. There are a number of aircraft types within this criteria that have a good safety record which would now have to revise the operation procedures in icing from those developed during certification.

Prior to completion of this IPHWG operational rule making activity the FAA issued NPRM's proposing Airworthiness Directives to modify the procedures for operation of the airframe de-icing systems of the affected airplanes. The proposed ADs would require activation of the airframe ice protection system at the first sign of ice formation anywhere on the aircraft, and thereafter operation continuously to minimize ice accretions on the airframe. This requirement was not supported by BAE Systems and some other manufacturers since the recommended and approved use of the de-icing systems was as established during certification and currently presented in the AFM. The certified system operation requires the crew to establish when approximately ½ inch of ice has accreted prior to operation of the manually cycled de-icing system. This procedure was developed and agreed with the authorities. There appears to be no safety concern on the BAE Systems aircraft affected (or indeed some other aircraft) which would require such a change to system operating procedures, as evidenced by the withdrawal of the AD's.

The FAA decision to withdraw the proposed AD's on some aircraft types was based on evidence supplied by the respective manufacturers. Typically this included information on the certification testing, margin to stall warning, the susceptibility to adverse handling characteristics and the information presented in the AFM. On BAE Systems aircraft types this included information on ice accretions appropriate to normal de-icing system operation and to delayed activation or system failure. The FAA has thereby accepted that some aircraft can continue to operate the de-icing system as certified and have recognized that the crew have adequate means to determine the required level of ice has accreted and then cycle the boots accordingly. On these aircraft there is no justification to require the de-icing system operation to be amended by the introduction of the IPHWG proposed Part 121 rule.

The intent of parts (a) (1), (2) and (b) parts (1) & (2) of the proposed Part 121 Operating rule was not to require the current fleet to have primary ice detection systems fitted but also to allow installed systems to be able to demonstrate compliance. Compliance with options (a)(2) or (b) would require changes to the certification of the ice protection system on some Part 23 and Part 25 aircraft which the FAA have previously agreed, by withdrawing the proposed AD's, are not required. The withdrawal of the AD was not dependent on the aircraft having an ice detector fitted.

A list of aircraft that have had the de-icing AD's withdrawn is detailed below. As can be seen there is potential for a considerable number of aircraft types to be affected by the introduction of the Part 121 rule as currently written.

It is BAE Systems contention that some aircraft that fall within the applicable criteria do not have a flight safety issue in icing, and as such should be allowed to operate as certified. BAE Systems propose that, since the Part 121 rules do not have a mechanism for accepting equivalent level of safety, the most effective way to accommodate this position is to revise the IPHWG proposed rule such that it would not be applicable to any aircraft type that has had the proposed de-icing AD withdrawn. This will recognize that the FAA have already determined the operation of these specific aircraft types in icing conditions meets the required safety levels and therefore removes the need for amending system operation by the Part 121 Ops rule.

List of Aircraft Eligible for Part 121 Operations with AD withdrawal

Part 25 Airplane models	**Docket No.**
Cessna Aircraft Company, Models 550, and 560 Series Airplanes.	99-NM-136-AD
Jetstream, Model 4101 Airplanes	99-NM-146-AD

Part 23 Airplane Models	**Docket No.**
LET, a.s., Model L-420 Airplanes	99-CE-39-AD
British Aerospace, Jetstream Models 3101 and 3201 Airplanes	99-CE-40-AD
Raytheon Aircraft Company, 90, 99, 100, 200, 300, 1900 Series Airplanes	99-CE-46-AD
Short Brothers & Harland Ltd., Models SC-7 Series 2 and SC-7 Series 3 Airplanes	99-CE-48-AD

Majority Response

As described in the minority position, the FAA withdrew several notices of proposed rulemaking (NPRM's) which proposed that the airframe pneumatic deicing boots be activated at the first sign of ice accretion. Some of these withdrawals were based upon data that substantiated the airplanes could safely operate if the IPS was operated as certificated. However, the FAA states that during the evaluation of the data the FAA did not consider whether the flightcrew has a clear means to determine when the IPS should be activated. For example, if the certificated method of IPS operation is manual activation when ½ inch of ice has accumulated, the FAA did not evaluate whether the flightcrew could determine the ½ inch was present. The FAA evaluated whether the data substantiated that the airplane could safely operate with the ½ inch of ice. If the substantiation was found to be acceptable the FAA withdrew the NPRM. Consequently, an NPRM withdrawal does not equate to a determination by the FAA that there is a clear means to know when to activate the IPS. The visual cues to operate the ice protection systems are accepted during the initial known icing certification of aircraft. However, the IPHWG review of the accident and incident data indicates that the flightcrew's observation of these visual cues may be difficult on some models during times of high workload, operations at night, or when clear ice has accumulated.

The Jetstream 4101 is one case where the NPRM was withdrawn and is described in the Airworthiness Directive Final Rule. Handling and performance flight tests were accomplished which substantiated that the airplane could be safely operated with certain ice accretions on the airplane. The tests included: Normal Operation of the Deicing Boots, ½ to ¾ inch of ice on the protected wing leading edges and up to 3 inches of ice on unprotected leading edges; Simulated Failure of the Deicing Boots, approximately 1 to 1½ inches of ice on all leading edges; and Ice Accreted During the Take-off Phase, a thin rough layer of ice accreted during the initial take-off phase to 400 feet, prior to operation of deicing boots. It might appear from this information that there is a factor of safety due to the tests with 1 to 1½ inches of ice, which would compensate for not having a clear means to know when the IPS should be activated. However, for the normal condition of activating the boots with ½ to ¾ inch of ice the handling and performance criteria are more stringent than for the failure condition with 1 to 1½ inches. It cannot be concluded that the tests conducted with large ice accretions justifies a clear means to know when to operate the deicing boots during normal operations is not needed.

There are many events in the accident/incident data base in which the ice protection system was operated either late or not at all. This led the IPHWG to conclude that the flightcrew need a clear means to know when to activate the IPS. The proposed rule is intended to address that need. It is possible to have an aircraft that can safely operate in icing conditions provided the IPS is operated as certificated, however the certificated means to know when to operate the IPS may not be clear. Therefore, the proposed rule should not exclude aircraft that had the proposed deicing NPRM's withdrawn.

Nonetheless, the majority of the IPHWG requests that the FAA further consider the airplanes for which the proposed Airworthiness Directives were withdrawn prior to publication of the NPRM for this proposed operating rule to assure that operating them as required by the NPRM will not degrade their performance or adversely affect the safety of their operation. This consideration may need to include a review of the visual means used to determine when the IPS should be activated to evaluate whether they are in fact inadequate under some circumstances.

The information in the database revealed that the phases of flight that presented the greatest risk due to airframe icing were those that were associated with low speed and relatively high angle-of-attack operation (i.e., approach, landing, go-around, and holding). Takeoff was excluded because the accidents related to that phase of flight were caused by improper ground deicing/anti-icing procedures; this has been adequately addressed by amendment 121-253 to 14 CFR [§ 121.629(b) and (c), "Operating in icing conditions"]. This conclusion was based primarily on the preponderance of icing accidents taking place during those phases, particularly approach and landing.

The IPHWG considered an alternative requirement that would apply in any case where an ice detector was not operational and/or installed. This alternative would require that, when the airplane is operating in conditions conducive to airframe icing, the IPS must be operated continuously. The group then considered how this procedure would apply to each phase of flight.

The database lists ten accidents as originating during cruise. In six of the ten accidents, the flight crew was aware of the ice accretion. In the remaining four accidents, very little relevant data was available. These data were insufficient to draw meaningful conclusions and the IPHWG determined that the cruise accident history did not substantiate rulemaking.

The database also lists a number of incidents in the cruise phase, of which at least five were potential accidents. Further examination of the incidents where sufficient data was available led the IPHWG to conclude that the crews were aware that ice was accreting and that operation of the IPS at the first sign of ice accretion would have prevented the incidents. Examination of these incidents caused the IPHWG to conclude that the cruise phase should be included in the rule. However, the IPHWG did not believe that continuous operation of the IPS while in conditions conducive to icing was warranted. The IPHWG was reluctant to require continuous operation of manually cycled ice protection systems in conditions conducive to airframe icing due to considerations of crew workload and a concern that it would introduce a procedure possibly leading to substantial non-compliance. The IPHWG felt that continuous operation of the IPS at the first sign of ice accretion was more appropriate and alleviated the concern with procedural non-compliance.

With respect to the climb, approach, landing, holding and go-around phases of flight, the IPHWG determined that the following factors substantiated requiring the continuous operation of the IPS while in conditions conducive to icing:

- An overall majority of events which originated in these phases of flight;
- A sufficient number of events in which the flight crew was confirmed to be

unaware of ice accretion, supplemented by a substantial number of events in which the flight crew awareness of ice accretion was unknown;

- High cockpit workload resulting in low residual flight crew attention;
- Frequent maneuvering, resulting in little opportunity for the flight crew to detect aerodynamic degradations due to icing;
- Maneuvering at relatively high angles of attack.

Minority position: FAA

The flightcrew must be provided with a clear means to know when to activate the IPS both for the initial activation and on a continuing basis. It is the FAA's position that the preamble does not adequately justify the acceptability of using the flightcrew's observation of airframe ice accretions as the sole means of knowing when to activate the ice protection system during cruise.

Section 4 of the preamble states that the flightcrew's observation of ice accumulations can be difficult during times of high workload, operations at night, or when clear ice has accumulated. The preamble does not discuss the acceptability of flightcrew observation of airframe ice accretions during cruise if the operations are at night or if clear ice has accumulated.

The preamble states in section 2 that there were accidents and incidents where the flightcrew was completely unaware of ice accumulation on the airframe. It is the FAA's position that the flightcrew must have a clear means to know when to activate the ice protection system and that reliance on visual observation of ice accretions on the airframe during cruise is not acceptable when consideration is given to operations at night and if clear ice has accumulated.

The FAA is also concerned with the flightcrew workload created during cruise, by an IPS that must be manually cycled. An IPS that is automatically cycled or operates on a continuous basis (e.g. an anti-icing system) does not create this additional workload and is not a concern. It is the FAA's position that the following factors result in an unacceptable burden on the flightcrew during cruise:

a. the additional flightcrew workload if the IPS is cycled manually,
b. it may be necessary to operate the IPS during all of the cruise phase,
c. cruise is the longest phase of flight, and
d. workload during cruise varies, but can be high when operating in congested areas.

Therefore, the FAA proposes as follows:

1) When the airplane is operated in airframe icing conditions, the rule should require activation of the ice protection system during all phases of flight except first and second segment climb (0 to 400 feet). Take off climb prior to the completion of second segment

climb is exempted because the accidents during this phase of flight are attributed to improper ground deicing/anti-procedures and not to inactivation of the IPS.

2) The rule should require that the airplanes be equipped with a system which automatically cycles the ice protection system or the ice detection system must be effective for the initial activation of the IPS and subsequent cycles if the IPS operates in a cyclical manner.

Majority Response

During the cruise phase, the IPHWG proposed rule as written would allow the use of visual observation of ice formation anywhere on the aircraft as the means of knowing when to activate the ice protection system during cruise. The FAA minority position would require continuous operation of the system during cruise. The cruise phase of flight typically has limited exposure to actual airframe icing due to the limited horizontal extent of icing clouds. Per the FAA Technical Report DOT/FAA/CT-88/8-1 "Aircraft Icing Handbook" (March 1991), Figure 1-32, 90% of all icing clouds will have a horizontal extent of less than 50 statute miles. Typical Part 121 turboprop aircraft have cruise speeds on the order of 275 to 300 KTAS. Based on these figures, 90% of the icing clouds will be transited on the order of 9 minutes. Based on the proposed guidance of a 3-minute maximum time interval, the crew workload would typically consist of four manual activation cycles during the cruise phase of flight.

For most phases of flight, the rule as proposed requires the use of conditions conducive to airframe icing as a means to determine when to operate the ice protection systems. However, the probability of encountering the appropriate temperature and visible moisture conditions far exceeds the probability of actually accreting ice. Per the FAA Technical Report DOT/FAA/CT-88/8-1 "Aircraft Icing Handbook" (March 1991), Figure 1-37, icing will occur a maximum of approximately 40% of the time spent in clouds with temperatures below freezing. This implies that if the system is required to be operated during the cruise phase in conditions conducive to airframe icing, there will be no actual airframe ice accretions greater than 60% of the time the system is required to be operated. Were the FAA proposal of operating the ice protection system continuously during cruise in based on clouds and temperature to be adopted, this increase in the amount of time that the flight crew would be required to operate the ice protection systems could indeed lead to increased workload concerns, particularly with aircraft certified with manual pneumatic de-ice systems.

Manually operating a pneumatic de-ice system on temperature and moisture cues is considered acceptable for short durations or for periods of increased risk. The vertical climb and descent phases of flight are typically of limited duration with respect to proposed guidance of a 3-minute maximum time interval for ice protection system operation. These flight phases also tend to transition clouds vertically, which also limits the duration of the exposure. The additional flight crew workload for aircraft with manual pneumatic de-ice systems during these relatively limited exposures was accepted by the majority of the group IPHWG as compensating. However, directing flight crews to operate a manual pneumatic de-ice system in such a manner over prolonged periods of cruise in benign cloud conditions would create a situation where the motivation to comply would be greatly reduced due to the requirement to expend effort to remove airframe ice that is not present.

In addition, the FAA proposed Airworthiness Directives in 1999 and 2000 to require the operation of the de-ice boots on certain airplane types at the first sign of formation anywhere on the aircraft with continued operation to minimize ice accretions. The appropriateness of this method of operation is still a controversial issue (See BAE/Cessna minority position on the topic). However, the requirements of the Airworthiness Directives are similar to the requirements of the IPHWG proposal as written and no known issues regarding crew workload have surfaced. The issues raised in this document in the BAE/Cessna minority position are not workload related.

Based on the above considerations, the alternative of manually operating the boots during the cruise phase of flight based on temperature and moisture conditions was not considered by the IPHWG to be warranted (based on examination of the accident and incident history) or practical (based on frequent operation of the system with no actual ice accretions and the longer exposure of the cruise phase of flight). As stated in the preamble and generally acknowledged by the IPHWG, flightcrew observation of ice accumulations can be difficult under some circumstances. The majority of the IPHWG feel that allowing this as written in the proposal for the cruise phase is mitigated by the guidance provided in the proposed advisory circular for AFM language, as follows:

- If an automatic cycling mode is <u>not</u> available, the system must be operated at short intervals (not to exceed three minutes) to minimize ice accretions. In addition, the system must be operated for at least one complete cycle immediately prior to:

a. Decreasing airspeed for holding or for maneuvering for approach and landing;

b. Commencing a holding turn;

c. Commencing the turn intended to intercept the final approach course inbound, including the procedure turn; and

d. Selecting landing flaps.

These actions will remove any ice accumulated during cruise without the crew's knowledge.

With respect to the second part of the FAA proposal, the majority of the IPHWG believe that adoption of the FAA minority position requiring automatic cycling of the ice protection system or an ice detection system effective for each cycle of the ice protection system would in effect disallow the use of manually operated ice protection systems in Part 121 operations due to the complexity of the certification issues which would ensue.

It has never been the intention of the IPHWG to challenge the basic icing certification of any airplane to which this retrospective operating rule would apply. The proposal to require all aircraft to be equipped with a system that automatically cycles or the use of an ice detection system that is effective for the initial activation of the IPS and subsequent cycles would require the re-certification of aircraft with pneumatic manual de-ice systems.

For automatic cycles, the design change entails more than the addition of a timed control function to actuate the boots. The effectiveness of an existing manual pneumatic de-ice system to operate in an automatic cycle mode would need to be evaluated. The de-ice system effectiveness with thin ice accretions is largely dependent on whether the pneumatic system design can supply sufficient air to rapidly inflate the boots in an automatic cycle. An evaluation of the pneumatic characteristics of the system would be necessary. The failure monitoring strategy would likely require redesign and evaluation. The system reliability would need to be reassessed based on the increased number of operation cycles that typically occur with automatic systems. In addition, the residual and intercycle ice accretions handling qualities effects would need to be evaluated, typically both with simulated ice shapes and in natural icing conditions.

The alternate suggestion of using an ice detection system that is effective for the initial activation of the IPS and subsequent cycles if the IPS operates in a cyclic manner also would require reopening basic icing certification. While technology exists to operate a manual ice detection system in this manner, no Part 121 aircraft has been certificated with this technology. The technology that does exist is advisory only and has not been certified as a primary ice protection system activation means with the associated system safety implications. Certification of such technology would likely require a extensive program to mature the technology, design a system around it including both control architecture and failure monitoring. Extensive flight-testing to verify system function and any effects on the aircraft handling qualities with residual or intercycle ice accretions would be required. The magnitude of these types of design changes is believed to be beyond the scope of an operating rule.

The majority of the IPHWG believe that if a retrospective re-certification of an individual airplane type's ice protection system should be found necessary, it should be required through the Airworthiness Directive process, not in an operating rule. The majority also believes that the adoption of the rule language as proposed would not result in unacceptable increase in crew workload and is the most feasible means to address this issue.

In some cases, airframe manufacturers have specified definitions of icing conditions relative to given airplane types. In the absence of type-specific information, conditions conducive to airframe icing may be considered to exist in flight at an outside air temperature at or below +2 deg. C. in clouds or precipitation.

The safety concern of when to exit icing conditions was partially addressed in 1996 by a series of AD's issued by the FAA. [Amendment 39-9698, AD 96-09-22 (61 FR 20674, May 7, 1996) is typical of these AD's.] The AD's require certain airplanes to exit icing when the conditions exceed the capabilities of the ice protection equipment. Generally, the visual cues for determining that the flight crew must act to exit icing conditions are subjective and can result in varying interpretations. Terms such as "unusually extensive ice," ice that is "not normally observed," and ice that is "farther aft than normally observed" are used in the AD's. These are all variable terms that are largely dependent on flight crew experience. The IPHWG concluded that less subjective means of determining when the flight crew should exit icing conditions are needed.

5. Technology

To ensure that viable means exist for compliance with any proposed methods of addressing the safety concerns, the IPHWG reviewed the current state of technology with regard to ice detectors and aerodynamic performance monitors.

Ice detector technology is sufficiently mature that there currently are available several methods that can reliably alert the flight crew as to when the IPS should be activated. This type of technology already has been certificated on various airplanes as either an advisory or a primary means of determining when the IPS should be activated. However, an ice detection system with the capability to alert the flight crew when to exit icing conditions would have to be able to detect when:

a. The icing conditions encountered exceed the criteria to which the airplane was certificated; or

b. Ice is accreting on surfaces of the airplane where it could prove hazardous and that were not addressed in the airplane's icing certification.

Some ice detection systems currently installed on airplanes have the capability to detect and alert the flight crew that ice is accreting on sensor elements of the detector. Depending upon the intended application of these detectors, ice accretions of approximately 0.1 mm to 1 mm and larger are detectable. However, these detectors have not been proven to operationally perform either of the functions identified in paragraphs a and b above.

Due to the unproven capabilities of ice detectors for the above application and the immature development of aerodynamic performance monitors, the IPHWG considered additional means for the flight crew to know when they should exit icing conditions.

There is an accident and incident history caused by the uncommanded deflections of reversible flight controls in both pitch and roll axes in icing conditions. These uncommanded deflections were the result of ice accreting ahead of the control surfaces, either aft of the protected area or on the protected area when the IPS was not activated. This resulted in airflow separation over a control surface. Such a flow separation changes the pressure distribution on the control surface. The resulting control force change may be quite large, with significant difficulty for the flight crew to manage. In some cases, control of the airplane may not be regained.

In the database there is no history of accidents or incidents due to uncommanded rudder deflections. Normal operation of the airplane does not expose the vertical stabilizer to high sideslip angles (angles of attack) that could cause the vertical tail to stall and result in uncommanded movement of the rudder; there is a large stall margin for the vertical tail. Due to engine inoperative and crosswind landing requirements, the rudder is designed for operation at high sideslip angles without force reversal. The IPHWG found no grounds for including the yaw axis in the proposed rule.

For irreversible flight controls, the control surface actuators are sized to maintain the control surface in its commanded position throughout the airplane's flight envelope, including high-speed dive. This results in the design loads for the actuators being larger than the loads induced by flow separation caused by ice accretions aft of the airplane's protected areas. Therefore, airplanes with irreversible flight controls are not subject to uncommanded control surface deflection caused by ice accretions.

It is feasible for the current ice detector technology to identify the existence of ice aft of the protected areas. Based on the accident and incident history and the current state of ice detector technology, the IPHWG recommended that the regulations be revised to address the known safety concern of ice accumulations aft of the airframe's protected areas on airplanes with reversible flight controls in the pitch or roll axis.

The IPHWG also acknowledged that, in lieu of an ice detector, it might be possible to use the flight crew's observation of ice accretion on reference surfaces, provided that the visual cues are substantiated for the specific airplane.

The relevant icing accidents and incidents occurred on airplanes equipped with pneumatic deicing boots. However, the accumulation of ice aft of the protected areas due to large droplet icing conditions can occur on any airplane, regardless of the type of IPS installed on it. Therefore, the IPHWG maintained that any revision to the current regulations should be applicable regardless of the type of IPS.

Definition of Terms

For the purposes of this proposed rule, the following definitions are applicable:

a. **Advisory ice detection system**: An advisory system annunciates the presence of ice accretion or icing conditions. The cockpit crew is responsible for monitoring the icing as defined in the AFM, typically using total air temperature and visible moisture criteria, visible ice accretion, or specific airframe ice accretion thickness, and activation by the cockpit crew of the anti-icing or de-icing system(s) remains a requirement. The advisory system provides information to advise the cockpit crew of the presence of ice accretion or icing conditions but it can only be used in conjunction with other means to determine the need or timing of anti-icing or de-icing system activation.

b. **Airframe icing:** Ice accretions on portions of the airplane on which supercooled liquid droplets may impinge, with the exception of the propulsion system.

c. **Anti-Icing**: The prevention of ice formation or accumulation on a protected surface, either by evaporating the impinging water or by allowing it to run back and off the surface or freeze on non-critical areas.

d. **Automatic cycling mode:** A mode of airframe de-icing system operation that provides repetitive cycles of the system without pilot selection of each cycle. This is generally done with a timer and there may be more than one timing mode.

e. **Conditions conducive to airframe icing:** Visible moisture at or below a static air temperature of +2 deg. C., unless otherwise substantiated.

f. **Deicing**: Removal or the process of removal of an ice accretion after it has formed on a surface.

g. **Irreversible flight controls:** All of the force required to move the pitch, roll, or yaw control surfaces is provided by hydraulic or electric actuators, the motion of which is controlled by signals from the cockpit controls. Loads generated at the control surfaces themselves are reacted against the actuator and its mounting and cannot be transmitted directly back to the cockpit controls.

h. **Large droplet conditions conducive to ice accumulation aft of the airframe's protected area:** Conditions containing a population of supercooled droplets sufficiently larger than those provided for in Appendix C to cause ice accretions aft of the protected areas. The accumulation mechanism aft of the protected surface may be by direct impingement and accretion or delayed freezing of large droplets that impinge further forward. These conditions may be aircraft dependent as a consequence of airfoil geometry and limits of protected areas.

i. **Monitored Surface**: The surface of concern regarding ice hazard (e.g., the leading edge of the wing).

j. **Primary ice detection system**: The means used to determine when the IPS must be activated. The system annunciates the presence of ice accretion or icing conditions and may also provide information to other aircraft systems. A primary automatic system automatically activates anti-icing or de-icing systems. With a primary manual system, the cockpit crew activates the IPS upon indication from the system.

k. **Reference Surface**: The surface where an ice detection sensor is located or where a visual cue is located remotely from the surface of concern regarding ice hazard (e.g., a propeller spinner).

l. **Reversible flight controls:** The cockpit controls are connected to the pitch, roll, or yaw control surfaces by direct mechanical linkages, cables, or push-pull rods such that pilot effort produces motion or force about the hinge line. Conversely, force or motion originating at the control surface (through aerodynamic loads, static imbalance, or trim tab inputs, for example) is transmitted back to cockpit controls.

1. <u>Aerodynamically boosted flight controls</u>: Reversible flight control systems that employ a movable tab on the trailing edge of the main control surface linked to the pilot's controls or to the structure in such a way as to produce aerodynamic forces that move, or help to move, the surface. Among the various forms are flying tabs, geared or servo tabs, and spring tabs.

2. <u>Power-assisted flight controls</u>: Reversible flight control systems in which some means is provided, usually a hydraulic actuator, to apply force to a control surface in

addition to that supplied by the pilot to enable large surface deflections to be obtained at high speeds.

m. **Static air temperature:** The air temperature as would be measured by a temperature sensor not in motion with respect to that air. This temperature is also referred to in other documents as "outside air temperature," "true outside temperature," or "ambient temperature."

n. **Substantiated visual cues**: Ice accretion on a reference surface identified in the AFM which is observable by the flight crew. Visual cues used to identify Appendix C ice will differ from those used to identify large droplet ice.

NOTE: These definitions of terms are intended for use only with this rule.

Discussion of the Proposed Rule

The FAA has reviewed and accepted the recommendations that were developed by the IPHWG and were approved by ARAC. The FAA proposes to amend the current Part 121 regulations in two areas:

Activation of IPS

The first area addresses the possibility of the flight crew failing to recognize that the airframe ice protection procedures should be initiated. The proposed rule would be applicable to airplanes that have a maximum certified takeoff weight less than 60,000 pounds. As discussed previously in the Discussion section of this preamble, airplanes with takeoff weights less than 60,000 typically have wing chord lengths of the size that have been involved in relevant icing-related accidents and incidents. The proposed rule would require:

- A primary ice detection system and initiation of any other procedures for operation in icing conditions specified in the AFM; or
- Both substantiated visual cues and an advisory ice detection system, either of which enable the flight crew to determine that the ice protection system must be activated, and initiation of any other procedures for operating in icing conditions specified in the AFM; or
- That during climb, holding, maneuvering for approach and landing, and any other operation at approach or holding airspeeds, when in conditions conducive to airframe icing, the IPS must be activated and the approved procedures for operating in airframe icing conditions must be initiated, and
- That during any other phase of flight, the IPS must be activated and operated at the first sign of ice formation anywhere on the aircraft, except where the AFM specifies that the IPS should not be used.

Each of these methods provides a clear means for addressing the safety concern of when the IPS must be activated.

Indication of Ice Accumulation Aft of the Airframe's Protected Areas

The second area of the proposed rule addresses the possibility of ice accumulations on the airplane that could lead to hazardous operating conditions if the airplane is allowed to stay in icing conditions. For the same reason stated above, the proposed rule would be applicable to airplanes that have a maximum certified take-off weight less than 60,000 pounds. Further, the rule would be limited to airplanes equipped with reversible flight controls in the pitch or roll axis because these aircraft can be subject to uncommanded control surface deflections caused by ice accretions. The proposed rule would require that:

- Visual cues must be substantiated that enable the flight crew to determine that the airplane is in large droplet conditions conducive to ice accumulation aft of the airframe's protected areas; or
- The airplane must be equipped with a caution level alert and its associated visual or aural means to alert the flight crew that the airplane is in large droplet conditions conducive to ice accumulation aft of the airframe's protected areas.

These proposed requirements address the known problem of large droplet ice accretions aft of protected surfaces causing uncommanded pitch or roll control surface deflection that may result in loss of control of the airplane.

The determination that the airplane is operating in large droplet conditions conducive to ice accumulation aft of the airframe's protected areas could be based on:

- A <u>direct</u> measurement of ice accumulations on the airframe, or
- An <u>indirect</u> measurement of supercooled liquid droplet diameters, or
- Visual observation of ice accumulations on the airframe.

The intent of the proposed rule is to detect when the airplane is experiencing these icing conditions. Therefore, "forecast icing conditions" are not to be considered when complying with this proposed rule.

Direct measurement could be a surface-mounted ice detector located aft of the protected areas that detects the presence of ice. Indirect measurement could be a device that is remotely located and the detection of icing conditions at the device's location can be correlated to the presence of ice on the airfoil surface. Direct observation of ice accretion on substantiated locations on the airframe can be an acceptable means of compliance.

The proposed rule would require that the pilot in command must take action to immediately exit the conditions upon determining that the airplane is in large droplet conditions conducive to ice accumulation aft of the airframe's protected areas unless, in the opinion of the pilot in command, it is necessary to delay such action in the interest of safety.

Level of Approval

The modifications to airplanes that will be necessary to comply with the proposed rule will likely be complex and will require thorough testing and analysis to ensure that they perform their intended function when installed on the airplane. Therefore, the FAA proposes that the modifications and AFM procedures used to comply with this regulation would be required to be approved through an amended or supplemental type certificate in accordance with 14 CFR Part 21. As discussed in FAA Order 8110.4B ("Type

Certification"), an amended type certificate might not involve a physical alteration to the type certificate for some type design changes.

The proposed rule is not intended to disapprove an existing icing certification. Therefore, it is not necessary to re-certificate an airplane for flight in icing.

In the process of obtaining the amended or supplemental type certificate, the pertinent rules that apply to any modification are contained in § 23.1301 and § 25.1301 ("Equipment -- Function and installation"). Paragraph (a) of these rules requires that the equipment, "Be of a kind and design appropriate to its intended function." The applicant would be required to show that the modifications necessary for compliance with this proposed rule meet the "intended function" of the Part 121 rule. This is consistent with the FAA's practice of compliance findings for the digital flight data recorder requirements of Part 121. ***(Insert the DFDR rule amendment number and Fed. Register citation)***

Compliance

The notice proposes a two year compliance time from the effective date of the final rule.

Reasons for Proposing a Part 121 Operations Rule

Part 121 covers all scheduled operations of airplanes with ten or more passenger seats and scheduled operations of all turbojets regardless of size. In addition, the "hub and spoke" route network of the U.S. air traffic system can concentrate large numbers of Part 121 operations within a single weather system. With occasional exceptions under 121.590, Part 121 operators are constrained to use only airports certificated under FAR 139. A given Part 121 operator is generally further constrained to only those Part 139 airports listed in its Operations Specifications. The flight crews of Part 121 operators generally do not carry approach charts for airports not listed in their Operations Specifications. During busy traffic periods, lengthy vectoring or holding for landing sequencing is common at these airports. When this vectoring results in exposure to undesirable conditions such as icing, the flight crews' options (except in case of emergency) are generally limited to tolerating the exposure or diverting to a pre-planned Part 139 alternate airport listed in their Operations Specifications.

Consideration was also given to Part 91 and Part 135 operations. Most aircraft operated under Part 135 and Part 91 have been subjected to AD's discussed above regarding activation of their de-icing boots at first signs of accretion and also regarding exiting icing in severe icing environments. These AD's were proposed for all aircraft with pneumatic de-icing boots that are certified for known icing operations. The proposed AD's regarding boot activation resulted in an FAA review of operating procedures and certification basis on the affected aircraft. The severe icing AD's provide generic visual cues that can provide a means to identify conditions conducive to ice accumulations aft of protected areas and require exiting the conditions upon detection. As a result of this aircraft review and/or application of AD's, a level of safety relative to initial ice accretions and severe icing environments has been established. These procedures are relatively recent and the full impact of these safety improvements is not reflected in the reviewed event database.

In addition, Part 91 and 135 operators are not constrained to Part 139 airports, and in fact often avoid them in the first place due to the factors discussed above. Even when they plan to use them, they are free to divert to any suitable airport in the given terminal area, of which there are often several. The lower air traffic density in which Part 91 and 135 operators consequently often operate also results in fewer holding delays and significantly more routing options in icing conditions. Under Part 91 the tactical flexibility increases even more due to the inclusion of many small-scale general aviation aircraft. Moreover, Part 91 and Part 135 aircraft are typically smaller-scale aircraft than those operated under Part 121. This smaller scale provides easier monitoring of ice accretions, estimation of ice thickness, and identification of severe icing cues.

The level of safety provided by the combination of the AD's, the recent review of the operating procedures, the ability to more readily evaluate ice accretions, and tactical flexibility provide a comparable level of safety to other Part 91 and Part 135 operational requirements. The proposed Part 121 rule change will enhance the level of safety to the segment of the traveling public that has the greatest exposure and subsequent risk associated with flight in icing. Therefore, the IPHWG believes that a Part 91 and Part 135 rule is not required.

Applicability to Part 23 and Part 25 Airplanes

The icing accident and incident database developed by the IPHWG showed that all the relevant accidents and incidents occurred on aircraft with wing chord lengths less than 10 feet. Based on this finding, the FAA has proposed a Part 121 rule that is applicable to airplanes with a maximum certified takeoff weight of less than 60,000 pounds. Since the proposed rule addresses the safety concerns of flight in icing for smaller aircraft (i.e., maximum takeoff weight less than 60,000 pounds), the FAA proposes that the rule be applicable to both Part 23 and Part 25 airplanes that are operated under Part 121.

Applicable Airplane Models Eligible for Operation under 14CFR Part 121

The following is a list of currently certificated Part 23 and Part 25 airplanes under 60,000 pounds, equipped with reversible flight controls in the pitch or roll axis. Inclusion in this list does not necessarily mean the airplane is used in Part 121 operations, however.

- Aerospace Technologies of Australia Models N22B and N24A.
- Aerospatiale ModelsATR-42 and ATR-72 series.
- Beech Model 99, 200, and 1900 series.
- British Aerospace Model HS 748 series.
- CASA Models C-212 and CN-235 series.
- Cessna Models 500, 501, 550/560 series, and 650 series.
- de Havilland Models DHC-6, DHC-7, and DHC-8 series.
- Dornier Models 228, 328-100 and 328-300.
- EMBRAER Models EMB-110O1, EMB-110P2, and EMB-120 series.
- Fairchild Models F27 and FH227 series.
- Fairchild Aircraft Models SA226 and SA227 series.
- Fokker Model F27 Mark 100, 200, 300, 400, 500, 600, 700, and 050 series.
- Frakes Aviation Model G-73 (Mallard) and G-73T series.
- Gulfstream Aerospace Model G-159 series.

- Harbin Aircraft Mfg. Corporation Model Y12 IV.
- Jetstream Models 3101/3201, BAe ATP, and 4101.
- **Lear models**
- Lockheed Models L-14 and L-18 series.
- McDonnell Douglas Models DC-3 and DC-4 series.
- Mitsubishi Heavy Industires Model YS-11 and YS-11A series.
- Pilatus Britten-Norman Ltd. Models BN-2A, BN-2B, and BN-2T.
- Raytheon Aircraft Company (formerly known as Beech Aircraft Corporation) Models 100 series, 200 series, 300 series, B300 series, 400A, Hawker 800 and 1000.
- Reims F406
- Saab 340 series and SAAB 2000..
- Sabreliner Corporation Models 40, 60, 70, and 80 series.
- Short Brothers Models SD3-30, SD3-60, and SD3-SHERPA series.
- SIAI-Marchetti S.r.I (Augusta) Models SF600 and SF600A.

FAA Advisory Material

In addition to the amendment proposed in this notice, the FAA has developed an Advisory Circular (AC) that provides guidance as to acceptable means of demonstrating compliance with this proposed rule. Comments on the proposed AC are requested by separate notice published elsewhere in this issue of the Federal Register.

Paperwork Reduction Act

The Paperwork Reduction Act of 1995 (44 U.S.C. 3507(d)) requires that the FAA consider the impact of paperwork and other information collection burdens imposed on the public. We have determined that there are no new information collection requirements associated with this proposed rule.

International Compatibility

In keeping with U.S. obligations under the Convention on International Civil Aviation, it is FAA policy to comply with International Civil Aviation Organization (ICAO) Standards and Recommended Practices to the maximum extent practicable. The FAA determined that there are no ICAO Standards and Recommended Practices that correspond to these proposed regulations.

Executive Order 12866 and DOT Regulatory Policies and Procedures
[APO is responsible for drafting the Regulatory Evaluation Summary. Summary of the economic evaluation prepared by APO will be inserted here.]

Economic Evaluation, Regulatory Flexibility Determination, International Trade Impact Assessment, and Unfunded Mandates Assessment

Proposed changes to Federal regulations must undergo several economic analyses. First, Executive Order 12866 directs that each Federal agency propose or adopt a regulation only upon a determination that the benefits of the intended regulation justify its costs. Second, the Regulatory Flexibility Act of 1980 requires agencies to analyze the economic impact of regulatory changes on small entities. Third, the Trade Agreements Act (19 U.S.C. section 2531-2533) prohibits agencies from setting standards that create unnecessary obstacles to the foreign commerce of the United States. In developing U.S. standards, this Trade Act also requires agencies to consider international standards and, where appropriate, use them as the basis of U.S. standards. And fourth, the Unfunded Mandates Reform Act of 1995 requires agencies to prepare a written assessment of the costs, benefits and other effects of proposed or final rules that include a Federal mandate likely to result in the expenditure by State, local or tribal governments, in the aggregate, or by the private sector, of $100 million or more annually (adjusted for inflation.)

In conducting these analyses, FAA has determined this rule 1) has benefits which do justify its costs, is not a "significant regulatory action" as defined in the Executive Order and is "significant" as defined in DOT's Regulatory Policies and Procedures; 2) will not have a significant impact on a substantial number of small entities; 3) reduces barriers to international trade; and 4) does not impose an unfunded mandate on state, local, or tribal governments, or on the private sector. These analyses, available in the docket, are summarized below.

Regulatory Flexibility Act

The Regulatory Flexibility Act (RFA) of 1980, (5 U.S.C. 601 et seq.) directs the FAA to fit regulatory requirements to the scale of the business, organizations, and governmental jurisdictions subject to the regulation. We are required whether a proposed or final action will have a significant impact on a substantial number of "small entities" as defined by the Act. If we find that the action will have a significant impact, we must do a "regulatory flexibility analysis."

International Trade

The Trade Agreement Act of 1979 prohibits Federal agencies from engaging in any standards or related activity that create unnecessary obstacles to the foreign commerce of the United States. Legitimate domestic objectives, such as safety, are not considered unnecessary obstacles. The statute also requires consideration of international standards and where appropriate, that they be the basis for U.S. standards. In addition, consistent with the Administration's belief in the general superiority and desirability of free trade, it is the policy of the Administration to remove or diminish, to the extent feasible, barriers to international trade, including both barriers affecting the export of American goods and services to foreign countries and barriers affecting the import of foreign goods and services to into the U.S.

In accordance with the above statute and policy, the FAA has assessed the potential effect of this proposed and has determined that it would have only a domestic impact and therefore no affect on any trade-sensitive activity.

Regulations Affecting Interstate Aviation in Alaska

Section 1205 of the FAA Reauthorization Act of 1996 (110 Stat. 3213) requires the Administrator, when modifying regulations in title 14 of the CFR in manner affecting interstate aviation in Alaska, to consider the extent to which Alaska is not served by transportation modes other than aviation, and to establish such regulatory distinctions as he or she considers appropriate. Because this proposed rule would apply to the certification of future designs of transport category airplanes and their subsequent operation, it could, if adopted, affect interstate aviation in Alaska. The FAA therefore specifically requests comments on whether there is justification for applying the proposed rule differently in interstate operations in Alaska.

Unfunded Mandates Reform Act

[APO is responsible for developing this analysis.]

The Unfunded Mandates reform Act of 1995 (2 U.S.C. §§ 1532-1538) requires the FAA to assess the effects of Federal Regulatory actions on state, local, and tribal governments, and on the private sector of proposed rules that contain a Federal intergovernmental or private sector mandate that exceeds $100 million in any one year. This action *[does or does not]* contain such a mandate.

Executive Order 13132, Federalism

The FAA has analyzed this proposed rule under the principles and criteria of Executive Order 13132, Federalism. We determined that this action would not have a substantial direct effect on the States, on the relationship between the national Government and the States, or on the distribution of power and responsibilities among the various levels of government. Therefore, we determined that this notice of proposed rulemaking would not have federalism implications.

Plain Language

In response to the June 1, 1998, Presidential memorandum regarding the use of plain language, the FAA re-examined the writing style currently used in the development of regulations. The memorandum requires federal agencies to communicate clearly with the public. We are interested in your comments on whether the style of this document is clear, and in any other suggestions you might have to improve the clarity of FAA communications that affect you. You can get more information about the Presidential memorandum and the plain language initiative at http://www.plainlanguage.gov.

Environmental Analysis

FAA Order 1050.1D defines FAA actions that may be categorically excluded from preparation of a National Environmental Policy Act (NEPA) environmental impact statement. In accordance with FAA Order 1050.1D, appendix 4, paragraph 4(j), this proposed rulemaking action qualifies for a categorical exclusion.

Energy Impact

The energy impact of the notice has been assessed in accordance with the Energy Policy and Conservation Act (EPCA) Pub. L. 94-163, as amended (42 U.S.C. 6362) and FAA Order 1053.1. It has been determined that the notice is not a major regulatory action under the provisions of the EPCA.

List of Subjects in 14 CFR Part 121

Aircraft, Aviation safety, Reporting and record keeping requirements, Safety, Transportation.

The Proposed Amendment

In consideration of the foregoing, the Federal Aviation Administration proposes to amend Part 121 of Title 14, Code of Federal Regulations, as follows:

PART 121—OPERATING REQUIREMENTS: DOMESTIC, FLAG, AND SUPPLEMENTAL OPERATIONS

1. The authority citation for Part 121 continues to read as follows:

Authority: 49 U.S.C. 106(g), 40113, 40119, 44101, 44701-44702, 44705, 44709-44711, 44713, 44716-44717, 44722, 44901, 44903-44904, 44912, 46105.

2. Add a new section 121.XXX to read as follows:

§ 121.XXX [Title].

After [a date 24 months after the effective date of the final rule], no person may operate an airplane with a maximum certified takeoff weight less than 60,000 pounds in conditions conducive to airframe icing unless it complies with this section. Conditions conducive to airframe icing are considered as visible moisture at or below a static air temperature of +2 deg. C., unless the approved Airplane Flight Manual provides another definition.

(a) When operating in conditions conducive to airframe icing:

(1) The airplane must be equipped with a primary ice detection system; when the ice protection system is activated, any other procedures for operation in icing conditions specified in the Airplane Flight Manual must be initiated; or

(2) Both substantiated visual cues and an advisory ice detection system must be provided, either of which enable the flight crew to determine that the ice protection system must be activated; when the ice protection system is activated, any other procedures for operation in icing conditions specified in the Airplane Flight Manual must be initiated; or

(b) If the airplane is not equipped to comply with the provisions of paragraph (a)(1) or (a)(2), then the following will apply:

(1) When operating in conditions conducive to airframe icing, the ice protection system must be activated prior to and operated during the following phases of flight, and any additional procedures for operation in icing conditions specified in the Airplane Flight Manual must be initiated:

(i) Take off climb after second segment, en route climb, and go-around climb;

(ii) Holding;

(iii) Maneuvering for approach and landing; and

(iv) Any other operation at approach or holding airspeeds

(2) During any other phase of flight, the ice protection system must be activated and operated at the first sign of ice formation anywhere on the aircraft, except where the Airplane Flight Manual specifies that the ice protection system should not be used.

(c) If the procedures specified in paragraph (b)(1) of this section are specifically prohibited in the Airplane Flight Manual, compliance must be shown with the requirements of paragraph (a)(1) or (a)(2).

(d) For airplanes with reversible flight controls for the pitch and/or roll axis:

(1) Visual cues must be substantiated that enable the flight crew to determine that the airplane is in large droplet conditions conducive to ice accumulation aft of the airframe's protected areas; or

(2) The airplane must be equipped with a caution level alert and its associated visual or aural means to alert the flight crew that the airplane is in large droplet conditions conducive to ice accumulation aft of the airframe's protected areas.

(e) For airplanes with reversible flight controls for the pitch and/or roll axis, the pilot in command must take action to immediately exit the conditions in which any ice accretion is occurring, upon:

(1) Determining that the airplane is in large droplet conditions conducive to ice accumulation aft of the airframe's protected areas; or

(2) Activation of the caution level alert required by (d)(2);

unless, in the opinion of the pilot in command, it is necessary to delay such action in the interest of safety.

(f) All procedures necessary for compliance with this section must be set forth in the Airplane Flight Manual.

(g) System installations and AFM procedures used to comply with this section must be approved through an amended or supplemental type certificate in accordance with Part 21 of this subchapter.

Issued in Washington, DC, on

U.S. Department of Transportation
Federal Aviation Administration

Advisory Circular

Subject: COMPLIANCE WITH REQUIREMENTS OF § 121.XXX, ______________	**Date:** Draft 2/21/01	**AC No:** 121-XX
	Initiated By: ANM-110	**Change:**

WORKING DRAFT -- NOT FOR PUBLIC RELEASE.

1. PURPOSE.

a. This Advisory Circular (AC) describes an acceptable means for showing compliance with the requirements of § 121.XXX, "______________," of Title 14, Code of Federal Regulations (CFR) Part 121, commonly referred to as Part 121 of the Federal Aviation Regulations (FAR). Part 121 contains the applicable aircraft operating requirements (for domestic, flag, and supplemental operations). The means of compliance described in this document is intended to provide guidance to supplement the engineering and operational judgment that must form the basis of any compliance findings relative to the requirements of § 121.XXX. Guidance includes considerations for:

- Installing a primary ice detection system; or
- Developing a method to alert the flight crew that the airframe ice protection system (IPS) must be activated, and revising the Airplane Flight Manual (AFM) concerning procedures for activating the airframe IPS; and
- A means for the flight crew to determine that they must exit icing conditions.

b. The guidance provided in this document is directed to airplane and engine manufacturers, modifiers, foreign regulatory authorities, and Federal Aviation Administration airplane type certification engineers and their designees.

c. Like all advisory circular material, this AC is not, in itself, mandatory, and does not constitute a regulation. It is issued to describe an acceptable means, but not the only means, for demonstrating compliance with the requirements for transport category airplanes.

Terms such as "shall" and "must" are used only in the sense of ensuring applicability of this particular method of compliance when the acceptable method of compliance described in this document is used. While these guidelines are not mandatory, they are derived from extensive Federal Aviation Administration and industry experience in determining compliance with the pertinent regulations.

d. This advisory circular does not change, create any additional, authorize changes in, or permit deviations from, regulatory requirements.

2. APPLICABILITY. The guidance provided in this AC applies to the operation, in conditions conducive to inflight airframe icing, of Part 23 (small) and Part 25 (transport category) airplanes with a maximum certified take-off weight less than 60,000 pounds and used in Part 121 operations.

3. RELATED DOCUMENTS.

a. **Regulations contained in Title 14, Code of Federal Regulations (CFR).**

§ 23.1301	Equipment - Function and installation
§ 23.1309	Equipment, systems, and installations
§ 23.1322	Warning, caution, and advisory lights
§ 23.1419	Ice protection
§ 23.1585(a)	Operating procedures
§ 25.1301	Equipment - Function and installation
§ 25.1309	Equipment, systems, and installations
§ 25.1316(b)	System lightning protection
§ 25.1321	Instruments Installation - Arrangement and visibility
§ 25.1322	Warning, caution, and advisory lights
§ 25.1333	Instrument systems
§ 25.1419	Ice protection
§ 25.1585(a)(6)	Operating procedures

Appendix C to Part 25

b. **Advisory Circulars (AC).** The AC's listed below may be obtained from the U.S. Department of Transportation, Subsequent Distribution Office, SVC-121.23, Ardmore East Business Center, 3341 Q 75th Avenue, Landover, MD 20785:

AC 20-73 Aircraft Ice Protection, dated April 21, 1971.

AC 20-117A	Hazards Following Ground Deicing and Ground Operations in Conditions Conducive to Aircraft Icing, dated December 17, 1982.
AC 20-115B	Radio Technical Commission for Aeronautics, Inc. (RTCA) Document RTCA/DO-178B, dated January 11, 1993.
AC 23.1309-1C	Equipment, Systems, and Installations in Part 23 Airplanes, dated March 12, 1999.
AC 23.1419-2A	Certification of Part 23 Airplanes for Flight in Icing Conditions, dated August 19, 1998.
AC 25-7A	Flight Test Guide for Certification of Transport Category Airplanes, dated March 31, 1998.
AC 25-11	Transport Category Airplane Electronic Display Systems, dated July 16, 1987
AC 25.1309-1A	System Design Analysis, dated June 21, 1988.
AC 25.1419-1	Certification of Transport Category Airplanes for Flight in Icing Conditions, dated August 18, 1999.

4. DEFINITION OF TERMS. For the purposes of this AC, the following definitions should be used.

a. **Advisory ice detection system**: An advisory system annunciates the presence of ice accretion or icing conditions. The cockpit crew is responsible for monitoring the icing as defined in the AFM, typically using total air temperature and visible moisture criteria, visible ice accretion, or specific airframe ice accretion thickness, and activation by the cockpit crew of the anti-icing or de-icing system(s) remains a requirement. The advisory system provides information to advise the cockpit crew of the presence of ice accretion or icing conditions but it can only be used in conjunction with other means to determine the need or timing of anti-icing or de-icing system activation.

b. **Airframe icing:** Ice accretions on portions of the airplane on which supercooled liquid droplets may impinge, with the exception of the propulsion system.

c. **Anti-Icing**: The prevention of ice formation or accumulation on a protected surface, either by evaporating the impinging water or by allowing it to run back and off the surface or freeze on non-critical areas.

d. **Automatic cycling mode:** A mode of airframe de-icing system operation that provides repetitive cycles of the system without pilot selection of each cycle. This is generally done with a timer and there may be more than one timing mode.

e. **Conditions conducive to airframe icing:** Visible moisture at or below a static air temperature of +2 deg. C., unless otherwise substantiated.

f. **Deicing**: Removal or the process of removal of an ice accretion after it has formed on a surface.

g. **Irreversible flight controls:** All of the force required to move the pitch, roll, or yaw control surfaces is provided by hydraulic or electric actuators, the motion of which is controlled by signals from the cockpit controls. Loads generated at the control surfaces themselves are reacted against the actuator and its mounting and cannot be transmitted directly back to the cockpit controls.

h. **Large droplet conditions conducive to ice accumulation aft of the airframe's protected area:** Conditions containing a population of supercooled droplets sufficiently larger than those provided for in Appendix C to cause ice accretions aft of the protected areas. The accumulation mechanism aft of the protected surface may be by direct impingement and accretion or delayed freezing of large droplets that impinge further forward. These conditions may be aircraft dependent as a consequence of airfoil geometry and limits of protected areas.

i. **Monitored Surface**: The surface of concern regarding ice hazard (e.g., the leading edge of the wing).

j. **Primary ice detection system**: The means used to determine when the IPS must be activated. The system annunciates the presence of ice accretion or icing conditions and may also provide information to other aircraft systems. A primary automatic system automatically activates anti-icing or de-icing systems. With a primary manual system, the cockpit crew activates the IPS upon indication from the system.

k. **Reference Surface**: The surface where an ice detection sensor is located or where a visual cue is located remotely from the surface of concern regarding ice hazard (e.g., a propeller spinner).

l. **Reversible flight controls:** The cockpit controls are connected to the pitch, roll, or yaw control surfaces by direct mechanical linkages, cables, or push-pull rods such that pilot effort produces motion or force about the hinge line. Conversely, force or motion originating at the control surface (through aerodynamic loads, static imbalance, or trim tab inputs, for example) is transmitted back to cockpit controls.

1. <u>Aerodynamically boosted flight controls</u>: Reversible flight control systems that employ a movable tab on the trailing edge of the main control surface linked to the pilot's

controls or to the structure in such a way as to produce aerodynamic forces that move, or help to move, the surface. Among the various forms are flying tabs, geared or servo tabs, and spring tabs.

2. Power-assisted flight controls: Reversible flight control systems in which some means is provided, usually a hydraulic actuator, to apply force to a control surface in addition to that supplied by the pilot to enable large surface deflections to be obtained at high speeds.

m. **Static air temperature:** The air temperature as would be measured by a temperature sensor not in motion with respect to that air. This temperature is also referred to in other documents as "outside air temperature," "true outside temperature," or "ambient temperature."

n. **Substantiated visual cues**: Ice accretion on a reference surface identified in the AFM which is observable by the flight crew. Visual cues used to identify Appendix C ice will differ from those used to identify large droplet ice.

> **NOTE:** These definitions of terms are intended for use only with respect to § 121.XXX.

5. COMPLIANCE WITH § 121.XXX: Determining static air temperature.

a. In the absence of more specific guidance provided by the manufacturer and approved by the FAA, § 121.XXX allows for the use of visible moisture and static air temperature at or below +2° C for determination of conditions conducive to airframe icing. If this provision is used, the flight crew should be able to easily determine the static air temperature.

b. The FAA anticipates that most types of airplanes to which § 121.XXX applies already incorporate a display of static air temperature available to the pilot. Existing displays that have been previously certificated need not be re-certificated. If the display is a new installation, the modification must be approved by the Aircraft Certification Service. If there is no such display, a placard can be provided showing corrections for temperature versus air speed to the nearest degree Centigrade in the region of interest (i.e., around 0 degrees).

c. Requiring the pilots to access hand-held charts or calculators in lieu of a placard is not an acceptable means.

6. COMPLIANCE WITH § 121.XXX(a)(1) and (2).

a. This section of the rule requires as an acceptable means of compliance:

1. For 121.xxx(a)(1), either a primary automatic or primary manual ice detection system.

2. For 121.xxx(a)(2), substantiated visual cues and an advisory ice detection system.

3. The applicant should present an ice detection system certification plan to the cognizant Aircraft Certification Office for an amended or supplemental type certificate. For Part 25 airplanes, the certification plan should cover compliance with §§ 25.1301, 25.1309, 25.1419, and any other applicable sections. For Part 23 airplanes, the certification plan should cover §§ 23.1301, 23.1309, 23.1419, and any other applicable sections.

b. **System Performance when Installed.** The applicant should accomplish a droplet impingement analysis and/or tests to ensure that the ice detector is properly located. The detector and its installation should minimize nuisance warnings, in accordance with §§ 23.1301 or 25.1301. The applicant must show that the modifications necessary for compliance with this proposed rule meet the "intended function" of the system required by this Part 121 rule.

c. **System Safety Considerations.** The applicant should consult AC 23.1309-1C or AC 25.1309-1A for guidance on compliance with § 23.1309 and § 25.1309, respectively. In accordance with those AC's, the applicant should accomplish a functional hazard assessment to determine the hazard level associated with failure of the ice detection system. The unannunciated failure of a primary ice detection system is assumed to be a catastrophic failure condition, unless the characteristics of the airplane in icing conditions without activation of the IPS are demonstrated to result in a less severe hazard category. The annunciated failure of a primary ice detection system is considered to be minor and requires the flight crew to avoid conditions considered to be conducive to icing or to conduct operations in accordance with FAR 121.XXX(a)(2), if substantiated visual cues and an advisory ice detector are available for the airplane; or FAR 121.XXX(b)(1). Failure of an advisory ice detection system is considered to be minor.

d. **Safe Operations in Icing Conditions.**

1. Both § 23.1419 and § 25.1419 require that the applicant demonstrate that the airplane is able to operate safely in the icing conditions defined in Appendix C to Part 25. It is not necessary to re-certificate the airplane for flight in icing to comply with § 121.XXX. However, the ice detection system should be shown to operate in the range of conditions defined by Appendix C.

2. Both § 23.1419 and § 25.1419 also require a combination of tests and analyses to demonstrate the performance of the ice detector and the system as installed on the airplane. This could include icing tunnel and icing tanker tests to evaluate the ice detector performance. Also required are analysis and flight tests in measured natural atmospheric conditions to demonstrate satisfactory performance of the system as installed on the

airplane. The approach used should result in activation of the IPS with the same amount of ice or less than would result from application of the approved existing AFM procedures. If this is not the case, the system may not be acceptable as a primary ice detection system for the purposes of § 121.XXX. Additional substantiation may be required to demonstrate that the airplane can safely operate with these larger ice accretions.

e. **Airplane Flight Manual (AFM).** The AFM should address the following:

- Operational use of the inflight ice detection system and any limitations; and
- Failure indications and appropriate crew procedures.

7. OPERATING PROCEDURES FOR § 121.XXX(a) & (b)

a. This section provides operating procedures to show compliance using various types of IPS's. Section 121.XXX (b) provides an option to the means defined in paragraphs 121.XXX(a)(1) and (a)(2). This alternative requires the operation of the IPS when the airplane is in conditions conducive to airframe icing during the following phases of flight:

- Take off climb after second segment, en route climb, and go-around climb;
- Holding;
- Maneuvering for approach and landing;
- Any other operation at approach and holding airspeeds;

In addition, during any other phase of flight, the IPS must be activated and operated at the first sign of ice formation anywhere on the aircraft, unless the AFM specifies that IPS should not be used.

It is not acceptable to use crew assessment of depth of ice as a discriminator in deciding when to operate a de-icing system. The intent is to permit current certified manual systems to be used in such a way that they replicate the effectiveness of an automatic system without the dependency on the crew to establish ice depths.

b. The following is an acceptable AFM change for compliance with paragraph 121.XXX (a)(2): With the approval of the FAA, the applicant may revise the Limitations Section of the FAA-approved AFM to include the following requirements for activation of the IPS:

When the flight crew determines from either the substantiated visual cues or the advisory ice detection system that the ice protection system must be activated:

- *For anti-icing systems:* The system must be operated continuously.

- *For de-icing systems:*
  - If an automatic cycling mode is available, it must be operated continuously at the available cycle rate most appropriate for the ice accretion rate.
  - If an automatic cycling mode is not available, the system must be operated at short intervals (not to exceed three minutes) to minimize ice accretions. In addition, the system must be operated for at least one complete cycle immediately prior to:

    a. Decreasing airspeed for holding or for maneuvering for approach and landing;

    b. Commencing a holding turn;

    c. Commencing the turn intended to intercept the final approach course inbound, including the procedure turn; and

    d. Selecting landing flaps.

    e. After gear and flap retraction on a go-around climb.

The airframe ice protection system may be selected off:

- *For anti-icing systems:* After the substantiated visual cues and the advisory ice detection system no longer indicate ice accretion or after leaving conditions conducive to airframe icing.
- *For deicing systems:* After completion of an entire deicing cycle after the substantiated visual cues and the advisory ice detection system no longer indicate ice accretion or after leaving conditions conducive to airframe icing.

c. The following is an acceptable AFM change for compliance with paragraph 121.XXX (b): With the approval of the FAA, the applicant may revise the Limitations Section of the FAA-approved AFM to include the following requirements for activation of the IPS:

When operating in visible moisture at or below a static air temperature of +2 deg. C unless a different condition is substantiated by test data.

During take off climb after second segment, en route climb, and go-around climb, holding, maneuvering for approach and landing, and any other operation at approach or holding speeds, the airframe ice protection system must be activated.

During any other phase of flight the ice protection system must be activated and operated at the first sign of ice formation anywhere on the aircraft except where the AFM specifies that the ice protection should not be used.

- *For anti-icing systems:* The system must be operated continuously.
- *For de-icing systems:*

- If an automatic cycling mode is available, it must be operated continuously at the available cycle rate most appropriate for the ice accretion rate.
- If an automatic cycling mode is not available, the system must be operated at short intervals (not to exceed three minutes) to minimize ice accretions. In addition, the system must be operated for at least one complete cycle immediately prior to:
  a. Decreasing airspeed for holding or for maneuvering for approach and landing;
  b. Commencing a holding turn;
  c. Commencing the turn intended to intercept the final approach course inbound, including the procedure turn; and
  d. Selecting landing flaps.
  e. After gear and flap retraction on a go-around climb.

The airframe ice protection system may be selected off:

- *For anti-icing systems:* After leaving conditions conducive to airframe icing.
- *For deicing systems:* Following completion of an entire deicing cycle after leaving conditions conducive to airframe icing.

8. COMPLIANCE WITH § 121.XXX(c)

a. **Requirement of the Rule.** Paragraph (d) of § 121.XXX is applicable to aircraft with a maximum certified takeoff weight less than 60,000 pounds and equipped with reversible flight controls in either the pitch or roll axis. The paragraph requires that:

- Visual cues must be substantiated to enable the flight crew to determine that the airplane is in large droplet conditions conducive to ice accumulation aft of the airframe's protected areas; or
- The airplane must be equipped with a caution level alert and its associated visual or aural means to alert the flight crew that the airplane is in large droplet conditions conducive to ice accumulation aft of the airframe's protected areas.

b. **Applicable Airplanes.** The applicable Part 23 and Part 25 airplanes have a maximum certified take-off weight of less than 60,000 pounds with reversible flight controls in the pitch and/or roll axis and are used in Part 121 operations. Consult with the aircraft manufacturer, cognizant certification office, and type data certificate to determine which model aircraft meet these criteria.

c. **Acceptable Means of Determining if Airplane is Operating in Large Droplet Icing Conditions Conducive to Ice Accumulation Aft of the Airframe's Protected Area.** There are several acceptable means for determining that the airplane is operating in large droplet conditions conducive to ice accumulation aft of the airframe's protected area. These include:

(1) Direct or Remote Measurement on a Monitored Surface:

(a) *Placement of Detectors.*

(i) For direct measurement, ice detectors are fitted directly onto the surface to be monitored. The detectors sense the presence and/or the thickness of ice that is accumulating aft of the protected area. They are usually flush-mounted (integrated on or within the skin). The monitored surface may vary from a spot of approximately one square inch to several square inches or larger.

(ii) For remote measurement, the sensing element is not directly fitted onto the surface to be monitored. An optical means (e.g., infrared or laser device) may be one means of compliance. The surface extent monitored by this system is usually larger than with direct measurements.

(b) *Ability to Sense Ice.* The applicant should demonstrate that the detector is able to detect ice accumulation aft of the protected area that requires crew action to exit icing conditions. (See paragraph 8.d. of this AC for an acceptable means of determining when the flight crew should exit icing conditions.)

(i) For direct measurement, an icing wind tunnel, icing tanker and/or a laboratory chamber may be used to evaluate the ability of the ice detector to detect ice.

(ii) For remote measurement, laboratory tests may be used to demonstrate the ability of the detector to detect ice on the monitored surface.

(c) *Detector Position.* The detector should be positioned such that it performs its intended function with considerations given to the following factors:

- Accretion characteristics of the monitored surface,
- Sensitivity of the airfoil to ice accretions,
- Thermal characteristic of the installation with respect to the generation of heat (direct measurement only),
- Physical damage from foreign objects,
- Early detection (response time),
- Not intrusive relative to ice accretion on the monitored surface (direct measurement only),

- Field of view relative to the monitored surface (remote measurement only),
- Obscuration due to atmospheric conditions (e.g. snow, clouds) (remote measurement only), and
- Any other appropriate factors.

(d) *Analysis, icing tankers, and icing wind tunnels* may provide information for location of the detector. In addition, laboratory tests may provide information for location of the remote detector.

(2) Remote Measurement Correlated to Ice Accumulation on a Monitored Surface. One method that could be used would be to provide indication of the conditions by discriminating droplet sizes. This method could provide an indication of conditions beyond those for which the airplane has been demonstrated.

(a) *Acceptable Settings.* Unless other acceptable means can be established, the device should be set to provide an indication when conditions exceed those specified in Appendix C, assuming a Langmuir E distribution for 50μm MVD droplets. The definition of a Langmuir E distribution may be found in the FAA Technical report DOT/FAA/CT-88/8-1, "Aircraft Icing Handbook" published March, 1991, updated September, 1993. The applicant should determine what droplet sizes might result in impingement aft of the protected surfaces. When the device detects conditions that exceed the Appendix C conditions, the "exit icing" signal should be activated.

(b) *Component Qualification.* The component level certification should verify that the device is capable of providing a reliable and repeatable signal. One method would be to perform testing in an icing tunnel. The droplet size distribution should bracket the signal point, with droplet distributions slightly below and slightly above the signal point. The test should be repeated at sufficient conditions of liquid water content and ambient temperature to ensure operation throughout the icing conditions defined by Appendix C and with droplet sizes up to 500 microns, or identify limitations as to the conditions where performance is degraded.

(3) Visual Means. This means can range from direct observation of ice accretions aft of the airplane's protected surfaces to observation of ice accretions on reference surfaces. Examples of visual means that could indicate to the flight crew that the airplane is operating in large droplet conditions conducive to ice accumulation aft of the airframe's protected areas include observations of:

- Accretions forming on unheated portions of side windows,
- Accretions forming on the aft portions of propeller spinners,
- Accretions forming on aft portions of radomes, and
- Water splashing on the windshields at static temperatures below freezing

Multiple cues may be required to meet the requirements of this rule.

(a) *Field of View.* Visual cues should be developed with the following considerations:

(i) Visual cues should be within the flight crew's vision scan area while seated and performing their normal duties.

(ii) Visual cues should be observable during all modes of operation (day, night, IMC).

(b) *Verification.* The applicant should verify the ability of the crew to observe the visual cues and reference surface. The visual cues should be evaluated from the most adverse flight crew seat locations during normal duties in combination with the range of flight crew heights. Consideration should be given to the difficulty of observing clear ice on the monitored or reference surface. If a reference surface is used, the applicant should verify that it correlates with conditions conducive to ice accumulation aft of the airframe's protected areas. Verification of the visual cues may be accomplished by testing in measured natural icing or simulated large droplet icing behind a calibrated water tanker aircraft.

d. **Acceptable Means of Determining When Flight Crew Should Exit Icing Conditions.** The flight crew should exit the icing conditions in which ice accretion is occurring if any amount of ice is detected, or correlated to ice accumulation, aft of the protected areas

e. **System Safety Considerations.** The applicant should consult either AC 25.1309-1A or AC 23.1309-1C, as appropriate, for guidance on compliance with §§ 25.1309 or 23.1309, respectively.

(1) Hazard classification. The following is a qualitative analysis that may be used for determining the hazard classification for compliance with this Part 121 regulation. Not all encounters with large droplet icing result in a catastrophic event. While definitive statistics are not available, given the volume of aircraft operations, and reported incidents that did not result in a catastrophe, a factor of around 1 in 100 is a reasonable assumption of the probability of a catastrophic event, if an airplane encounters large droplet conditions conducive to ice accumulation aft of the airframe's protected areas. Based on the above assumption, the hazard classification of an unannunciated encounter with "large droplet conditions conducive to ice accumulation aft of the airframe's protected areas" may be considered as *severe major* or hazardous (10^{-7}) in accordance with AC 25.1309-1A or AC 23.1309-1C, respectively.

(2) Frequency of occurrence. The Appendix C conditions were designed to include 99% of icing conditions. Evaluation of icing data has indicated that the

probability of encountering icing outside of Appendix C droplet conditions is on the order of 10^{-2}. The applicant may assume this probability for encountering the large droplet conditions conducive to ice accumulation aft of the airframe's protected areas. It should be considered as an average probability throughout the flight.

(3) Numerical safety analysis. For the purposes of a numerical safety analysis, the applicant may combine the probability of equipment failure with the probability, defined above, of encountering large droplet conditions conducive to ice accumulation aft of the airframe's protected areas. Therefore, if the applicant uses the above analysis for the hazard classification and the above probability of encountering the specified large droplet conditions (10^{-2}), it follows that the probability of an unannunciated equipment failure should be less than 10^{-5}.

f. **System Performance when Installed.**

(1) The ice detector system installed for compliance with § 121.XXX(c) is intended to detect ice that forms due to large supercooled droplets that exceed those specified in Appendix C. Flight tests in measured natural icing conditions (required by § 23.1419 and § 25.1419) should be conducted to ensure that the system does not produce nuisance warnings when operating in conditions defined by Appendix C.

(2) The low probability of finding conditions conducive to ice accumulation aft of the protected areas makes natural icing flight tests impractical as a means of demonstrating that the system functions in conditions exceeding Appendix C. The applicant may use flight tests of the airplane under simulated icing conditions (icing tanker) or icing wind tunnel tests of a representative airfoil section to demonstrate the proper functioning of the system and to correlate the signals provided by the detectors and the actual ice accretion on the surface.

> **NOTE**: The measured natural icing flight tests required by § 25.1419 are only applicable for conditions that are defined by Appendix C.

g. **Software and Hardware Qualification.** For guidance on software and hardware qualification, the applicant should consult RTCA/DO-178, "Software Considerations in Airborne Systems and Equipment Certification," and RTCA/DO160D, "Environmental Conditions and Test Procedures for Airborne Equipment."

h. **Airplane Flight Manual**. For any changes to the limitations and normal procedures section of the AFM, the aircraft type certificate holder should be consulted to ensure compatibility with the flight characteristics of the particular model aircraft.

(1) For ice detection systems, the AFM should address:

(a) Operational use of the ice detection systems and any limitations of the system; and

(b) Failure indications and associated crew procedures.

(2) For visual means of compliance, the AFM should contain procedures that describe the visual means used to indicate that the airplane is operating in large droplet conditions that are conducive to ice accumulation aft of the airframe's protected areas.

(3) The following are acceptable AFM changes regarding actions the flight crew should take after there is an indication of ice aft of the protected areas. Changes to the Limitations Section of the AFM must be approved by the FAA.

(a) Revise the Limitations Section of the FAA-approved AFM to require the pilot in command to immediately take action to exit the conditions in which any ice accretion is occurring, unless in the opinion of the pilot in command, it is necessary to delay such action in the interest of safety.

(b) Revise the Normal Procedures Section of the FAA-approved AFM to include the following:

- In order to avoid extended exposure to flight conditions that result in ice accumulations aft of the protected areas, the pilot in command must immediately take action to exit the conditions in which any ice accretion is occurring, unless in the opinion of the pilot in command, it is necessary to delay such action in the interest of safety.

- Avoid abrupt and excessive maneuvering that may exacerbate control difficulties.

- Do not engage the autopilot.

- If the autopilot is engaged, hold the control wheel firmly and disengage the autopilot.

- If an unusual roll response or uncommanded roll control movement is observed, smoothly but positively reduce the angle-of-attack.

- Do not extend flaps during extended operation in icing conditions. Operation with flaps extended can result in a reduced wing angle-of-attack, with the possibility of ice forming on the upper surface further aft on the wing than normal, possible aft of the protected area.

- If the flaps are extended, do not retract them until the airframe is clear of ice.

- Report these weather conditions to Air Traffic Control.
- Maintain airspeed awareness and follow minimum speed guidelines per AFM procedures.
- Continue to follow these procedures until it can be determined that there are no ice accretions aft of the protected surface.

9. **FLIGHT CREW TRAINING.** Training in the use and procedures for the equipment required by § 121.XXX should be included in an operator's approved training program. Additionally, all pilots employed in operations under Part 121 should be given annual training in accordance with the approved methods in the operator's training program.

L&D HWG Status Report

28 March 2001 TAEIG Meeting

Handout 21

Discussion Items

- 25.415 Ground Gust
- 25.865 Fire Protection of Flight Controls, Engine Mounts, and other Structure
- Combinations of failure in 25.671(c)(2) and 25.1309
- 25.671(c)(3) - Jammed Flight Control Loads
- Ground Handling, Towing, and Landing Descent Velocity Tasks
- TOR for 25.301(b) Flight Loads Measurement

25.415 Ground Gust

- WG Report, AC & a draft NPRM
  - Submitted at the December 2000 TAEIG meeting
  - ALPA Rep Jim Bettcher asked for further explanations regarding pilot restraint of the flight controls while gust locks disengaged – not standard pilot practice
  - Discussed at March 6-8 L&DHWG meetings. Consensus was that the draft criteria are sufficiently conservative to cover
  - However it was agreed to do additional work – 3 manufactures w/ manual flight controls
  - ECD 15 June 2001

25.415 Ground Gust (cont.)

- Operational Issues
  - Some evidence that aircraft are being operated with ground gust peak velocities in excess of 65 KCAS
  - There is no requirement for the pilot to restrain the flight controls after gust locks are disengaged and while taxiing.
  - These issues can not be resolved by the L&D HWG (is not able to handle operational issues)
  - TAEIG guidance requested.

will document conclusions in working group report

make simple rec that FAA coordinate w/ another issues group

is aircraft design a limitation?

Could be placed in flight manual

25.865 Fire Protection of Flight Controls, Engine Mounts, and other Structure

- Status
  - Rolls-Royce tests using the draft AC methodology for lab determination of material temperatures has revealed that the selected test procedure is not adequate. Additional testing must be done. This is be coordinated with the FAA Tech Center
  - The initial consensus that the reference material could be addressed as "4000 series steel" is no longer supported. The FAA proposes "4130" steel.
  - Also, it is no felt that we can not proceed without a rule change to 25.865 as previously proposed.
  - The new L&DHWG FAA focal, Todd Martin is redirecting the Task Group. to resolve issues
  - The L&DHWG is working a new schedule for completion of this task; will not know until Tech Ctr testing is completed; will provide schedule at 10/01 mtg

Roll Royce testing
2 inch diameter bar - material temps did not stabilize
steel for add testing coordinating / Tech Ctr
From

Combinations of failure in 25.671(c)(2) and 25.1309

- Background
  - Progressed at Sept L&D HWG meeting
  - Airframe manufacturers are investigating the impact of the new rules in AC 25.1309 regarding peak risk and the new 25.671 requirement regarding latent failure together with the FAA issue paper
  - Former members of the flutter task team are to provide input on the flutter issues
- Status
  - This task has not been progressed since our FAA focal retired in Jan. New focal, Todd Martin is tasked with replanning.

25.671(c)(3) - Jammed Flight Control Loads

- Status report
  - Previous agreement reached on load conditions following flight control jam with the exception of the gust velocity for flaps extended conditions
  - Flaps extended gust velocity data from several sources were obtained and analyzed at March HWG meeting
  - Agreement on the flaps extended gust velocity was achieved.
  - Submittal to TAEIG at this meeting

671e only speaks to 60% of gust velocity

25.671(c)(3) - Jammed Flight Control Loads (cont'd)

Proposed text for AC 25.671

For clarity, it is proposed to separate the gust conditions for high lift devices retracted / extended as follows:

(iii) Structural Substantiation. The loads considered as ultimate should be derived from the following conditions at speeds up to the maximum speed allowed for the jammed position or for the failure condition:

(1) Balanced maneuver of the airplane between 0.25g and 1.75g with high lift devices fully retracted and in en-route configurations, and between 0.6g and 1.4g with high lift devices extended,

(2) Vertical and lateral gusts corresponding to 40% of the limit gust velocity specified at Vc in FAR/JAR 25.341 with high lift devices fully retracted,

(3) Vertical and head-on gust velocity of 17 fps with high lift devices extended.

risk that FAA will come back at 100% vertical + lateral gusts

TORs for Ground Handling, Towing, & Landing Descent Velocity (Assigned 28 Sept 2000)

- Ground Handling & Towing
  - The task group is collecting operational data to evaluate potential revisions to the requirements.
  - Details on existing and new gear configurations have been collected.
  - Progress is on track per work plan approved by TAEIG in Dec.

TORs for Ground Handling, Towing, & Landing Descent Velocity (Assigned 28 Sept 2000)

- Landing Descent Velocity
  - The task group is evaluating the full range of parameters that are applicable to defining loads as a function of descent velocity.
  - Details on existing and new gear configurations have been collected.
  - Additional FAA measured landing descent velocity data are required for Airbus wide-body and Boeing 777.
    - Heathrow airport has been selected. Data will be obtained in July of this year
  - Progress is on track per work plan approved by TAEIG in Dec.

- lot of energy absorption in trucks down main landing gear
- looking at a lot of (parameters) that contribute to peak loads

TOR for 25.301(b) Flight Loads Measurement

- Awaiting for this task to be published in the Federal Register, unofficial JAA Study Group has been moving forward L+D HWG has been keeping ~~abreast~~ abreast